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# Experimental investigation of the tractor engine performance using diesohol fuel

Behdad Shadidi [a], Talal Yusaf [b,*], Hossein Haji Agha Alizadeh [a], Barat Ghobadian [c]

[a] Bu-Ali Sina University, Hamedan, Iran
[b] National Centre for Engineering in Agriculture, Faculty of Engineering & Surveying, University of Southern Queensland, Toowoomba, 4350 QLD, Australia
[c] Tarbiat Modares University, Tehran, Iran

## HIGHLIGHTS

- Diesohol is a new fuel mixture (diesel and biotethano).
- Tractor performance using diesohol results is comparable with diesel.
- UHC concentration was decreased using diesohol.
- $CO_2$ concentration was increased using diesohol.

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## ABSTRACT

Diesohol fuel is a mixture of diesel and bioethanol fuels in which the ratio of bioethanol is less than 15%. In this research work, performance of a tractor engine (Massey Ferguson 399) using diesohol fuel was investigated. In these circumstances, the concentration of UHC and $CO_2$ emissions in the exhaust pipe were measured and analyzed. The engine was run at several speeds (1600–2000 rpm). The obtained results reveal that, when using diesohol fuels, the power and torque of the MF-399 tractor engine are increased by 3.17–8.50% and 1.75–10.28% respectively when compared to diesel fuel. This is due to a relatively more complete combustion of ethanol because of its high oxygen content. The fuel consumption and specific fuel consumption are also increased by 7.32–15.81% and 4.37–7.44% respectively due to low calorific value of ethanol compared to diesel fuel. The analysis showed that when diesohol is used, the rate of UHC is decreased but $CO_2$ emission is increased. In brief, by using diesohol fuels, especially E6 blend in comparison to diesel fuel, engine performance and emissions are improved without any changes in engine structure for diesohol application.



## 1. Introduction

Energy is the main input of industry and technology. Most of the world's energy consumption is produced from petroleum, gas and coal. Today, environmental concerns, a steady increase in petrol prices and gradual depletion of oil reserves have prompted researchers to examine reliable substitutes for fossil fuels. Over the past 25 years, worldwide petroleum consumption has steadily increased, resulting in higher standards of living, transportation and trucking, and increased use of plastics and other petrochemicals [5]. In 1985, total worldwide petroleum consumption was 2807 million tons and in 2008, the figure reached 3928 million tons, with an average annual growth rate of almost 1.5% [4]. However, the petroleum is a finite source for fuel that is rapidly becoming more scarce and expensive [9]. In addition, petroleum-based products are one of the main causes of anthropogenic carbon dioxide ($CO_2$) emission to the atmosphere. The current transportation sector worldwide is entirely dependent on petroleum-derived fuels [3]. One-fifth of global $CO_2$ emissions are created by the transport sector [12], which accounts for some 60% of global oil consumption [15]. Around the world, there were about 806 million cars and light trucks on the road in 2007 [19]. These numbers are projected to increase to 1.3 billion by 2030 and to over 2 billion vehicles by 2050 [21]. This growth will affect the stability of ecosystem and global climate as well as global oil reserves. The pollution caused by automobiles is known to be one of the major sources of air toxics in many urban centers around the world [2,24]. Because of these reasons, many extensive research works have been carried out or are underway all over the world to find optimum alternative fuels and renewable energies.

The most significant advantage of these fuels compared to conventional ones is pollution reduction because of non-sulfur content and oxygen content [11,22]. Using alcohol as fuel attracted a lot of

* Corresponding author. Tel.: +61 7 4631 2691x1373.
*E-mail address:* yusaft@usq.edu.au (T. Yusaf).

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researchers to mix it with the other fuels or use it as neat in internal combustion engines in past years, since it has environmental and economic benefits in comparison to fossil fuels.

Using ethanol and diesel blends in diesel engines has been studied by many researchers. High purity ethanol (>95%) is required to blend it with diesel engines [7]. In a study, the effects of ethanol–diesel (E5, E10) fuel blends on the performance and exhaust emissions were investigated experimentally. A single cylinder, four-stroke, direct injection, naturally aspirated diesel engine was used. The tests were performed at varying engine speeds between 1000 and 1800 rpm while keeping the engine torque at 30 N m. The results showed that brake specific fuel consumption and emissions of nitrogen oxides ($NO_x$) increased and emissions of carbon monoxide (CO) and total hydrocarbon (THC) decreased with ethanol–diesel fuel blends [6]. Researchers also used diesel, biodiesel and ethanol fuel blends on diesel engine. The parameters considered were engine power, torque and fuel consumption. Results indicated that adding oxygenated compounds to blends reduced the engine power and torque and increased the average SFC for various speeds [20]. In an investigation, the effect of ethanol addition (2%, 4%, 6% and 8% in volume) to ultra-low sulfur diesel fuel on the emissions of a direct injection (DI) diesel engine. With the increasing amount of ethanol in the fuel blends, the THC and CO emissions decreased but $NO_x$ emission increased when compared to the diesel fuel [10]. In another study, usage of diesel–ethanol blends on performance of diesel engine was investigated. Results showed that fuel consumption increased but CO concentration decreased [14].

Tractors and combines account for the largest share diesel fuel consumption in the agricultural sector in Iran. Based on the diversity of applications and working conditions along with annual working hours, tractors are the major diesel fuel consumers among agricultural machineries. Therefore in the present investigation, diesohol fuel which is a mixture of diesel fuel and bioethanol was considered to evaluate performance and exhaust emissions of a tractor engine (Massey Ferguson 399, referred to as MF399 in this research). In this case, net diesel fuel was selected as base fuel for comparison. The significant properties of diesohol were measured. Then, performance and exhaust emissions of MF399 engine using diesohol fuels were measured, analyzed and compared with diesel fuel.

## 2. Fuel preparation and experimental procedure

Diesohol fuel is a mixture of diesel and bioethanol in which the ratio of bioethanol in the mixture is less than 15%. Diesel fuel was obtained from a conventional Iranian diesel station and ethanol was prepared from cane molasses by 99.6% purity. The diesohol fuel blends are prepared based on volume percentage (E0D100, E2D98, E4D96, E6D94, E8D92, E10D90 and E12D88). These volume percentages were chosen because more than 15% ethanol does not mix with diesel fuel [20]. In Fig. 1, the letter 'D' stands for 'Diesel Fuel' and the letter 'E' stands for 'Ethanol'. Each number represents the volume percentage of each diesohol fuel. For example, E10D90 means that the diesohol blend contains 90% diesel fuel and 10% bioethanol. The volume percentage of diesohol fuel blends are presented in Fig. 1. The results of diesohol fuel blends on engine performance and emissions were compared with diesel fuel. A number of important properties of diesohol blends were also measured.

The experimental set up consists of an MF399 tractor engine, a PERKINZ A63544 type, six cylinder four stroke CI engine. The engine test bed consists of an NJ-FROMENT Σ5 dynamometer (Fig. 2), and a gas analyzer. The experimental setup is illustrated in (Fig. 3). The general specifications of the test engine are given in Table 1.

A MAHA gas analyzer model MGT5 was used to measure $CO_2$ and HC emissions. Table 2 shows technical data for this gas analyzer. The engine was run at several speeds (1600–2000 rpm). Torque, power, fuel consumption and emissions were measured for the performance analysis. Each test was repeated three times to ensure the reliability of the data. The engine was gradually loaded, and the speed was automatically reduced as the load increased.

## 3. Results and discussion

### 3.1. Fuel properties

The diesohol fuel blends were prepared. The diesohol fuel is a fuel mixture that contains diesel fuel and bioethanol fuel (lower 15%). Some important properties of diesohol fuel blends were measured these are summarized in Table 3.

### 3.2. Engine performance

After the engine reached the stable working conditions for each test, power, torque, fuel consumption, specific fuel consumption and exhaust emissions were measured and analyzed. There are seven experiments for each parameter and experiments have been done in 3 repetitions.

#### 3.2.1. Engine power

Experimental results of the engine power, using conventional diesel and diesohol blends at different diesohol fuel blends and engine speeds are presented in Fig. 4a and average changes for the engine power at all engine speeds is presented in Fig. 4b.


**Fig. 1.** Diesohol fuel blends.


**Fig. 2.** The NJ-FROMENT Σ5 dynamometer.